Geophysical Survey Methods
BP/ARCO Yerington Mine
Yerington, NV.

The purpose of the investigation is two-fold: 1) locate detectable dry wells in 5 locations and 2) identify detectable pipelines as indicated on the attached client provided figure. Our approach will be to employ EM-61, EM-31 terrain conductivity, shallow focus terrain conductivity, ground penetrating radar, and electromagnetic utility-locating methods.

Dry Well Search

It is our understanding that the approximate location of the dry wells will be staked in the field by Brown and Caldwell in advance of field activities and that the wells may have a metallic lid or grate associated with them. The area will then be investigated in areas where reliable field data can be collected in a 200-foot radius (roughly 3 acres at each location) around the suspected well location. High sensitivity metal detection (EM-61), terrain conductivity (EM-31), and ground penetrating radar (GPR) will be utilized in an effort to delineate the location of each well.

The following is a partial list of equipment used to locate detectable metallic and nonmetallic structures:

- Geonics EM-61 High Sensitivity Metal Detection
- Geonics EM-31 terrain conductivity meter
- Sensors and Software ground penetrating radar (GPR) unit
- RD electromagnetic utility-locating transmitter w/ matched receiver
- Fisher TW-6 M-scope - shallow focus metal detector

EM-61 High Sensitivity Metal Detection

The EM-61 transmitter generates a primary field of short pulses of electromagnetic energy that travel downward and outward. This energy becomes "trapped" in conductive materials and causes a secondary magnetic field to be generated in these materials. Between pulses, the receiver measures the voltage of the decay curve of this secondary magnetic field, which is proportional to the conductivity of the subsurface materials.

The geophysics crew will establish a grid and EM-61 voltage readings are taken, recorded and stored in a digital polycorder at 2.5-5-foot intervals along north-

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south lines spaced 5-feet apart. These data are downloaded to a laptop computer and processed in the field. Contour maps will be generated to assist in identifying anomalous areas that may be associated with USTs. Shallow focus terrain conductivity and ground penetrating radar (GPR) will be used to further characterize the source of significant EM-61 anomalies. The surface trace of detected features will be marked on the ground with spray paint and/or stakes with flagging ribbon.

The EM-61 is capable of detecting a 55-gallon drum up to a depth of 3 meters under favorable conditions. We recommend a minimum 10-foot buffer between the survey area and any metallic or metal bearing surface cultural features such as cars, metal signs, or aboveground piping which could severely compromise the quality of the data. Reliable EM-61 data cannot be collected over areas covered with reinforced concrete.

EM-61 Data Collection

EM-31 Terrain Conductivity

A Geonics EM-31 terrain conductivity (TC) meter will be used in an effort to locate detectable changes in the soil which might indicate the presence of a backfilled excavation, piping or possible dry well. The EM-31 (an electromagnetic

EM-31 Data Collection

induction instrument) consists of two coils (transmitter and receiver) mounted on either end of a 12-foot-long plastic boom. An alternating current is applied to the transmitter coil, which sends a primary electromagnetic (EM) field into the ground. This primary field induces eddy currents in buried conductive material that is

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encountered, and these eddy currents generate a secondary magnetic field. This secondary magnetic field is measured at the receiver and compared to the primary field in terms of the component in phase with the primary field (in-phase) and the component out of phase with the primary magnetic field (the quadrature component). The out-of-phase component is converted to read conductivity in millimhos per meter.

The geophysics crew will establish a grid and EM-31 voltage readings will be taken, recorded and stored in a digital polycorder at 2.5-foot intervals along north-south lines spaced 5-feet apart. These data will be downloaded to a laptop computer and processed in the field. **Contour maps will be generated to assist in identifying anomalous areas that may represent buried structures.** Anomalous areas will be demarcated using spray paint and/or wood stakes with flagging ribbon.

The EM31 provides a rapid method of measuring the ground conductivity, but only to a depth of about 6 meters with the bulk of the information being derived from the upper 1 to 2 meters. We recommend a minimum 20-foot buffer between the survey area and any metallic or metal bearing surface cultural features such as cars, metal signs, or aboveground piping which could severely compromise the quality of the data. Reliable EM-31 data cannot be collected over areas covered with reinforced concrete. **Changes in soil conductivity may not be apparent in areas backfilled with soils similar to background or in areas where cultural features (i.e. utilities or structures) are present.**

Electromagnetic utility locating and GPR techniques will be used to further characterize the source of anomalies identified in the EM-31 data.

Ground Penetrating Radar

We will employ GPR methods to identify detectable features in areas that are covered with reinforced concrete. Our approach will be to use a Sensors and Software ground penetrating radar unit in an effort to identify possible sources of identified anomalies. A high frequency radio signal is transmitted into the ground via the antenna. As radio waves propagate into the ground, these signals are reflected off structures with differing electrical properties. These reflected signals are then captured by the receiver and are presented as vertical profiles on the GPR unit.


GPR Data Collection

Semicontinuous (32 scans per second) GPR profiles will be collected within each grid using a 250 or 500-MHz antenna along parallel transects at a two-foot line separation at a range of 60 nanoseconds. These data are collected in "wheel mode", where a digital odometer connected to the wheel of the SmartCart is used to track the distance traveled by the antenna. Digital data were viewed by the operator in real time on a color screen, and saved for later processing.

GPR data are reviewed and processed using GPR-Slice (V5.0). GPR records consist of a number of scans which, when viewed together, form a continuous image. Each scan is made up of a specified number of samples.

GPR-Slice creates time-slice plan view maps of GPR-data for small time intervals – which can be converted to depth intervals if the dielectric constant of the materials is known. Essentially, each slice map represents the amplitude variations in the GPR signal within a specified depth range (such as 1.0 to 1.5 feet). The processing flow in GPR-Slice is as follows:
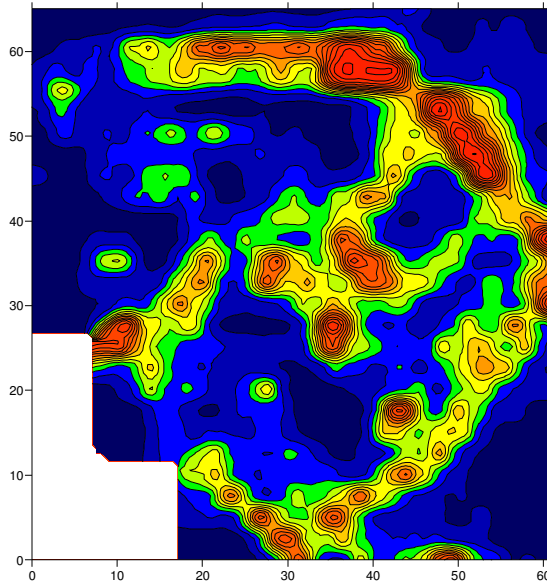
Sample 3-D GPR Data revealing the location of fiberglass product and vent lines

- Enter the information parameters for the GPR data set, such as name of project, time range for the data, GPR system used, navigation method.

- Reverse the data, if necessary

- Convert the data if 16 bit data were acquired

- Apply appropriate gains and/or filters to the data

- Slice and resample

- Grid the GPR slices

- Display and save data

The end product of GPR slice is several (generally 5 or more) time-slice plan-view maps representing GPR signal amplitudes within a specified time window.

Final printouts using GPR-Slice consist of a color scheme and transform scheme whereby each GPR reflection amplitude is assigned a certain color. In general, the raw, unfiltered /ungained data as well as the filtered and gained data are reviewed

for each transect. GPR data collected within each area is compared with those we have determined are most likely representative of background data. Where the GPR signal amplitude and character differed greatly from the background signature, an anomaly is interpreted. **GPR-Slice maps for each grid are then reviewed for possible footing-like signatures.**

The performance capability of GPR is dependent on the soil electrical conductivity at the site. If the soil conductivity is high, attenuation of the radar signal in the soil can severely restrict the maximum penetration depth of the radar signal. Under favorable conditions depth of penetration can be greater than 10 feet, however, average depths of GPR penetration in the Southwest tend to range between 3-5 feet. Soils high in clay content and moisture will have higher signal attenuation. GPR surveys should be performed in the dry season if at all possible, especially at California sites. Soil moisture, especially in high-clay soils, only increases the radar attenuation rates, further limiting the radar performance. It should be noted that GPR data collection

Fisher Shallow Focus Terrain Conductivity

requires large areas of flat and level ground where continuous data can be collected. Roughly 1 acre of data can be collected in a rectangular flat level area each day. Spectrum will determine if site or soil conditions preclude the use of GPR at this location.

Pipeline Search and Anomaly Follow-up

EM-Utility Locating

Passive and active EM utility-locating methods will be used in an effort to identify possible sources of EM-61, EM-31 and GPR anomalies and to delineate the surface trace of detectable underground utilities and abandoned piping associated with the Yerington Mine processes.

Passive locating is possible when electrically conductive conduits are energized by ambient radio frequencies (RF) that are often produced by 50/60 cycle electrical, radio, audio, television, and communication transmissions. A receiver tuned to these frequencies can be used to locate the re-radiated signal emitted by the conductor (i.e., conduit).

Active locating is initiated by conducting an EM signal at a known frequency (8 and 33 kHz for this site) on a conduit exposed at the surface. A receiver, tuned to these frequencies, is then used to locate the signal maxima (or surface trace) of the applied signal.

In non-metallic piping, cleanouts, and drains that are accessible, a micro transmitter (sonde) attached to fiberglass probes will be inserted into openings and the transmitted signal from the sonde will be identified on the ground surface using a hand held receiver. The length of probe inserted into the pipe depends on the diameter, condition, and construction of the pipe. Typically access is required every 100-250 feet along the piping. This can be accommodated through drain grates, clean outs, or exposed and open ends of piping. It should be noted that client provided assistance (such as a forklift or front loader) may be required to access these locations due to the heavy construction materials associated with mining facilities.

In addition to the sonde, a camera will be inserted into accessible pipelines in question to determine rough construction and a general condition of materials. This data will be recorded and supplied to the client for further review.

Utility location using the RD4000

It should be understood that the location of subsurface objects and utilities is dependent upon the recognition of physical phenomena at the ground surface. These phenomena can be magnetic fields or electromagnetic waves that give rise to a surface expression which in turn is interpreted as representative of subsurface objects. These waves, however, may be attenuated and/or distorted by a number of factors including soil moisture, corrosion, and proximity to other surface and subsurface facilities.

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